Defining the HRA Analysis Task

in HRA Method Benchmarking – Approaches and Outcomes in the International Empirical Study

JA Forester (Sandia), VN Dang (PSI), E Lois (US NRC)

presented by VN Dang

9th Int. Conf. on Probabilistic Safety Assessment and Management (PSAM9)
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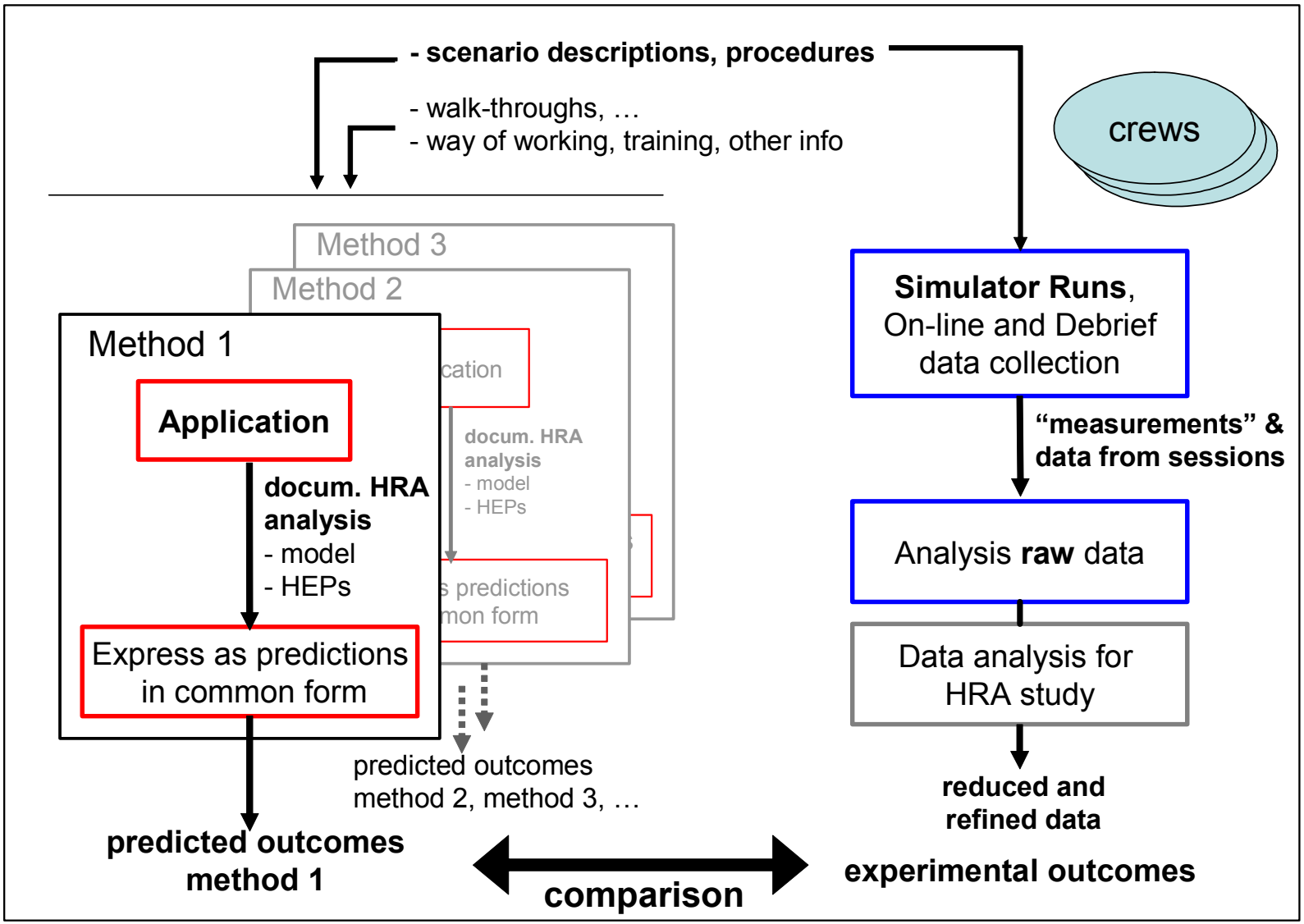
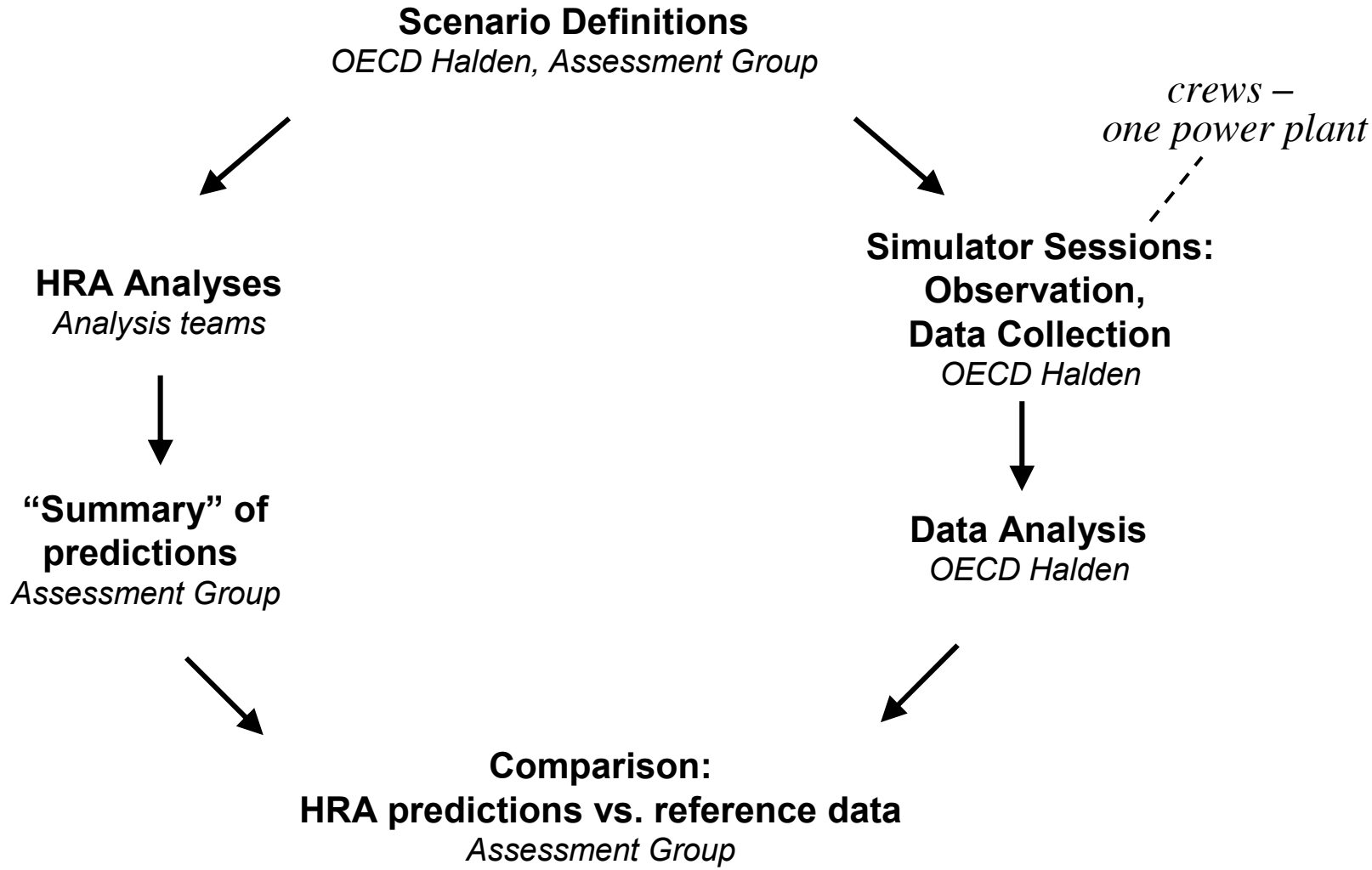
Defining the HRA Analysis Task in HRA Method Benchmarking – Approaches and Outcomes in the International Empirical Study

- **The HRA task in the Empirical Study**
  - **What the teams were asked to do**
- **Constraints and how these were addressed in the study design**
- **Conclusions**

The views expressed are those of the authors and do not necessarily represent the views of the U.S. NRC and other organizations mentioned.


- scenario descriptions, procedures
- walk-throughs, …
- way of working, training, other info
crews
Method 3
Method 2
Method 1
Application
docum. HRA analysis
- model
- HEPs
Express as predictions in common form
predicted outcomes method 1
docum. HRA analysis
- model
- HEPs
predictions
mon form
predicted outcomes
method 2, method 3, …
Simulator Runs, On-line and Debrief data collection
"measurements" & data from sessions
Analysis raw data
Data analysis for HRA study
reduced and refined data
experimental outcomes
comparison

Tasks of the Empirical Study



Scope of the HRA Task

A General HRA Process

- Identification of human activities of concern
- Definition of Human Failure Events (HFEs)
- Quantification of the probabilities of the HFEs

HRA Task in Empirical Study (pilot)

- Defined HFEs are provided to HRA teams
- Quantification of the HFEs
  - qualitative analysis
  - modeling and quantification
  - documentation
  - report driving factors and associated operational expression(s)

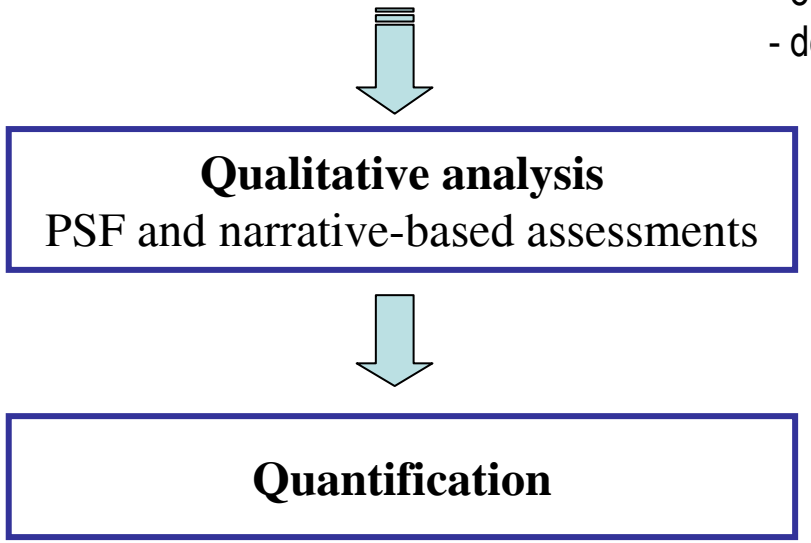
Observations on the HRA Task in the Empir. Study

- **HFE identification is excluded in order to ensure**
  - HRA teams are analyzing the same HFEs
  - uniform (consistent) scenario models, HFE success criteria, and assumptions across HRA teams

- It would be worthwhile to **assess identification and other parts** of the HRA general process **in future comparisons** against empirical data.
  - Better exercise more recent methods that emphasize “context” as a major driver of performance

Teams do still need to perform qualitative analyses

- HFEs are defined on a functional level



- scenario, plant info
- performance conditions
- operator aids incl. procedures
- description of training, crews, work practices

There are constraints on the HRA analyses

- No possibility for HRA teams to
  - observe operator crews in simulator (in the defined scenario or other scenarios)
  - interact with training staff and operators to discuss training, experience, and work practices (e.g. how they use procedures, etc.)
- Due to practical considerations
  - 12 HRA analysis teams
  - ensuring same information and assumptions

- In the Empirical Study, these constraints were addressed by
  - Characterization of the performance environment, the crews, and their aids included in the information package
  - Clarification question and answer (Q&A) process during the analysis
  - All questions and answers distributed to all teams

HRA Information Package : reference information and study materials

Administrative information and general instructions

1. **Overview (of the information package) and instructions to the HRA teams**
2. **Administrative information and agreement forms**
3. **Study outline**

Information on the scenario, the performance environment, the crews, and their aids

4. **HAMMLAB information**
5. **Scenario description and HFEs**
6. **Characterization of the crews, their work practices and training**
7. **Procedures used in HAMMLAB**

Forms for submittals

8. **Forms for the responses of the HRA teams**

HRA Team submittals (response package)

Form A for each HFE : "free-form, open-ended" questionnaire

1) **HEP**
2) **driving factors**
3) **"operational expressions"**

Form B for each HFE : "closed-form" questionnaire

- **present HRA predictions in common terminology**
- **form based on HERA* taxonomy**

* HERA: Human Event Repository and Analysis, cf. NUREG/CR-6903

documentation of HRA analysis and quantification (all HFEs)
as in a PRA

HRA Submittals: Form A

separate form for each HFE

1) HEP value (mean and uncertainty measures)

2) summary of the most influencing factors and why they are important

- both positive and negative
- identified through the HRA method
- using the terminology of the HRA method

3) qualitative discussion "operational expressions"

a. predicted difficulty or ease

b. reasons for this difficulty or ease

- How will the driving factors be manifested in the crews' performances ?
- What behaviors / responses do you expect to see ?

Items 2 and 3 ask the teams to present their analysis results in ways different from a normal HRA.

HRA Submittals: Form B

based on HERA Taxonomy (NUREG/CR-6093)

Part 1 overall event / scenario

plant and event overview
(base case / complex case SGTR)

General trends across HFEs

Dependencies among HFEs

Part 2 (per HFE)

Cognition / Activity Type for this HFE

- Detection / Interpretation / Planning / Action / Indeterminate

Dominant error type

- Commission / Omission / neither dominates / not addressed
- Slip / Lapse / Mistake / Circumvention

Contributory Plant Conditions

Contributory Factors

- **11 factors:** time, complexity, experience and training, procedures, ergonomics, etc
- **+ communication, team dynamics**
- **sub-factors**

Positive

- **relative importance** of factors
- identified **sub-factors**
- comment / explanation

Negative

- **same as for positive factors**

1. Conclusions – HRA in an empirical assessment of methods

- **The various HRA process sub-tasks** (identification, qualitative analysis, quantification) **need to be addressed by appropriate design for the benchmarking study methodology**
  - **The need to address the sub-tasks separately** is confirmed by the experience with this study
  - **Part-studies or a study with phases for the sub-tasks**, where the HRA teams can be "re-synchronized"
  - **Avoid propagating divergent assumptions** due to interpretation of the defined scenario, etc.
- **The Int. HRA Empirical Study has focused on the quantification part of the methods, but …**

2. Conclusions – HRA Task

- **The Int. HRA Empirical Study has focused on quantification**
  - **Significant qualitative analysis** elements are included
  - **Level and nature of the analysis** performed by the HRA analysis teams to understand the scenario and the factors **varied significantly among HRA teams**
    - **Task analysis long considered essential to HRA**
    - **but older methods do not specify explicitly how this should be done**
    - A study design with **multiple teams per method** would be needed to **separate team from method effects** in the study results
- **To some extent, the Empirical Study was deliberately designed to show the maximum potential of each method, when used well**

3. Conclusions – HRA Task

- **Some constraints on HRA Analysis**
  - **observations in the simulator, interactions with training staff and crews**
  - general agreement from the teams that the **information basis was adequate, esp. when study constraints are considered**
  - **1st pilot phase results has provided teams with additional information on crew behaviors and the qualitative variability in the crew performances**
    - **as a result, may expect shortcomings to have reduced importance in next phases**

Benchmarking Human Reliability Analysis (HRA) Methods Against Simulator Data – Method for the Comparison

JA Forester (Sandia), VN Dang (PSI), A Bye (OECD Halden),
E Lois (US NRC), GW Parry (US NRC), J Julius (Scientech)

presented by VN Dang

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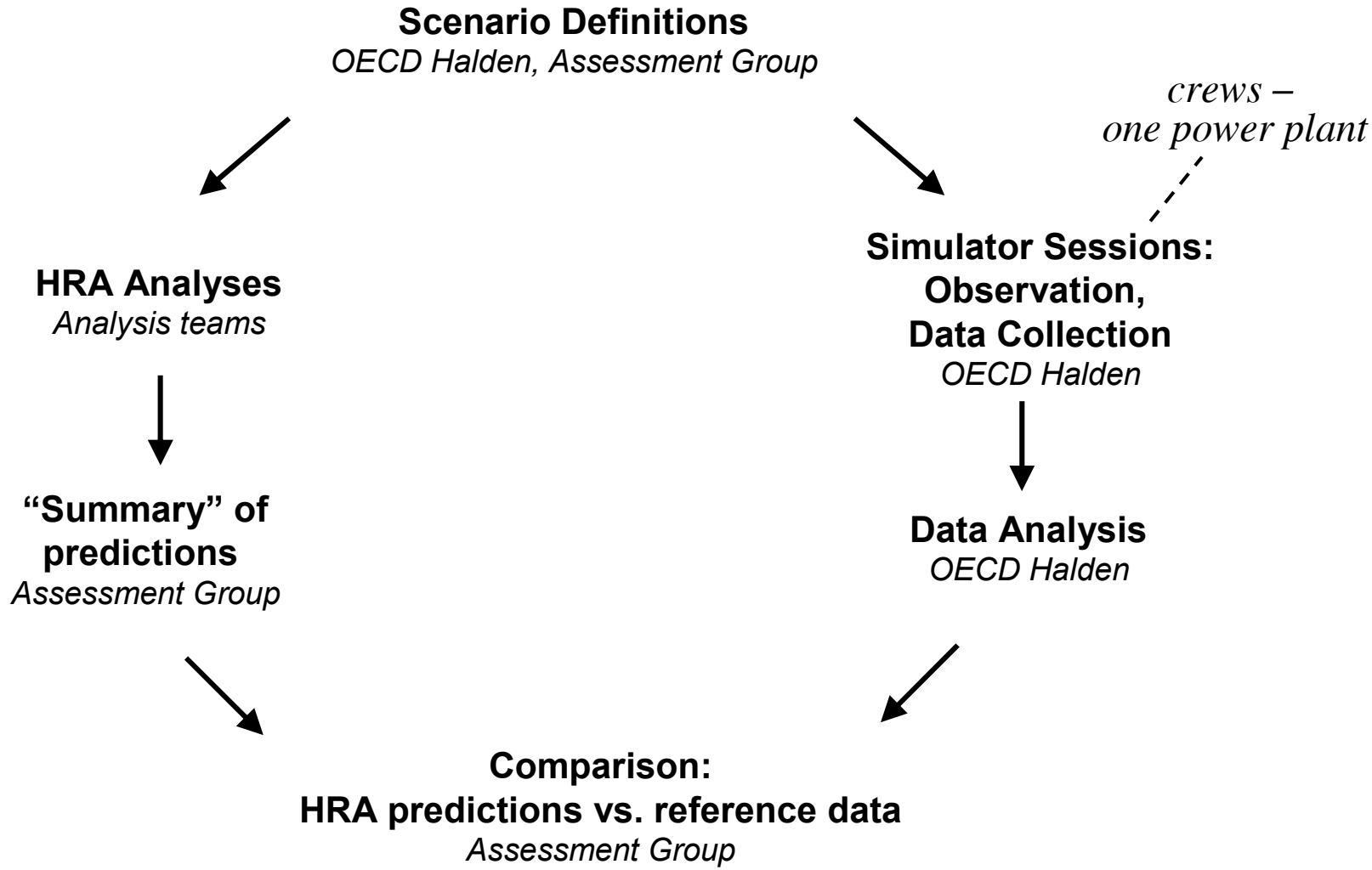
Tasks of the Empirical Study



Benchmarking Human Reliability Analysis (HRA) Methods Against Simulator Data – **Method for the Comparison**

- **Elements to be compared**
- **Comparison Process**
  - **Predicted outcomes, reference data, comparison**
- **Driving factors and operational expressions**
- **Other criteria in the assessment**
- **Outlook**

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Elements of comparison

correspond to three parts of Response Form A

1) **Failure probability of the HFE (HEP)**
   - measure of ease or difficulty of the operator action
2) **driving factors**
   - important **performance shaping factors** (PSFs)
   - important **aspects of the context**

     esp. relevant **for methods that focus on context-specific failure narratives**
3) **"operational expressions"**
   - basis for PSF rating and importance
   - **behaviors or difficulties that may be observed**
   - in terms of domain, **in terms of nuclear power plant operation**

Pilot first phase did not address quantitative results of methods

- First phase addressed 2 of 9 HFEs of SGTR scenario
  - related HFEs (isolation of faulted SG) in base and complex scenario variants
- To be addressed when remaining 7 HFEs are used
  - on-going work (2008)
- Quantitative comparison should be based on more HFEs
  - relative comparisons to be emphasized over comparison of absolute value, i.e. can check ranking of HFEs of each method

Comparison Process - Predicted Outcomes

What are the predicted outcomes?

- **Clarification, Review and Summary of HRA team submissions**
  - with input from the HRA Teams
- **Express in "common" terminology**
  - Team responses on Form A use method-specific terminology
  - HERA-based Form B supported the "translation"
- **Emphasis on operational expressions**
  - **made clear the scope and definitions of the PSFs in the methods**
  - **made the predictive analysis results directly comparable to simulator study observations**

Comparison – Reference Data

- Analysis of simulator data
  - Understanding performance of each crew and the influences from set of diverse raw data
  - Aggregating performance across the 14 crews
    - How did they do as a group?
- Identifying driving factors for the HFE
  - Observed difficulties and behaviors are related to factors
  - What are the important drivers of performance in this scenario?
    - performances are viewed as a set
    - variability across crews is factored out

Assessment of prediction vs. empirical reference data

What constitutes a match?

- At the driving factor level (factoring out crew-to-crew variability)
  - Factor is identified as a negative and was observed as a negative
  - Factor is identified as a positive and was observed as a positive
- Operational expressions
  - Predicted difficulty (or ease) was observed

Assessment does not consider importance of driving factors

- **Only the direction (positive or negative) is considered**
- **“Driving factors” or important PSFs combines weight and rating of PSF**
  - **For some methods, input factors can be identified but their importance to the HEP is not clear**
  - **Importance of factors is not comparable across methods**
    - i.e. “somewhat negative”, “negative”, “very negative”
    - ranking is a possibility (most important, least important)
  - **HRA analyst may identify a driving factor but method is not sensitive**

Other criteria in the assessment

Additional assessment of the method and analysis, based on comparison

- **Insights for error reduction**
  - Can potential measures for error reduction be identified from the analysis?
- **Impact of the PSF influences on the HEP**
  - If a PSF is identified as important in the qualitative analysis, can this be seen in its contribution to the HEP?
  - Is the HEP sensitive to these PSFs?
  - To what PSFs is the HEP sensitive?
- **Guidance of the method and traceability of the analysis**

Conclusions and outlook – comparison method

- **The emphasis on "operational expressions" has been essential to interpretation of PSFs**
- **The need to associate observed behaviors and difficulties in the simulator to PSFs has**
  - made weaknesses of HRA method guidance more evident
  - pointed out specific ways in which the guidance can be improved
- **Assessment of quantitative results of methods is on-going**
  - emphasis to be placed on ranking of HFEs
- **Comparison approach is one of major aspects of establishing the assessment study methodology.**

Your input is welcome: HWR-844, NUREG/IA-216

Halden Work Report (HWR-844)
May 2008
to appear as NUREG/IA-216

International HRA Empirical Study – Pilot Phase Report

Description of Overall Approach and First Pilot Results from Comparing HRA Methods to Simulator Data

E. Lois, V.N. Dang, J. Forester, H. Broberg,
S. Massaiu, M. Hildebrandt, P.Ø. Braarud,
G. Parry, J. Julius, R. Boring, I. Männistö, A. Bye

HWR-844

OECD HALDEN REACTOR PROJECT

INTERNATIONAL HRA EMPIRICAL STUDY -
PILOT PHASE REPORT

DESCRIPTION OF OVERALL APPROACH AND FIRST PILOT RESULTS FROM COMPARING HRA METHODS TO SIMULATOR DATA

by

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Session D-8, Wednesday 13:30

Data, results, and insights from the HRA Empirical Study

MERMOS Team

Session D-9, Wednesday 15:30

Enhanced Bayesian THERP (VTT) Team

ESREL'08, PSA'08

Additional HRA Analysis Teams

2007-2008 Study Phases

Phase 1 **2007 - May 2008**

- Pilot, **to establish methodology**. Produced some **preliminary results** on HRA methods.
- Almost complete, report May 2008
- Used two HFEs of SGTR

Phase 2 **Spring 2008**

- Analysing and comparing **rest of HFEs in the 2 SGTR scenario variants**
- Will provide more **results for the whole SGTR**
- Also **more results** on **quantitative predictions of** HRA methods
- Still uses the first analyses from the HRA teams

Phase 3 **2008 - March 2009**

- Analysing **LOFW scenario** (2 variants)
- **New HRA analyses by the HRA teams**, with increased knowledge of the Halden crews etc, since phase 1 has been thoroughly discussed and reported.
- To be reported in 2009.